

## **COS 598: Adv. Topics in CS – Image Processing and Analysis**

**Spring 2022: Section 2**

**Instructor: Prof. Terry Yoo**

### **Homework Assignment 4:**

#### **Demonstrating Frequency and Scale – Creating a Hybrid Image**

This assignment asks you to explore some concepts of frequency and scale space with a hands-on exercise. You may use any image software tools at your disposal to accomplish this task. The online YouTube tutorial uses Photoshop. I was able to complete this exercise using a combination of Apple's Photos application, Microsoft Powerpoint, and FIJI, the free, online image viewer tool from NIH.

##### **1. Background**

A famous illusion (that originated at MIT) is the hybrid image of Marilyn Monroe and Albert Einstein. When closely viewed, the image looks like Einstein, but at a distance, the image resembles Monroe.

What is happening: Distance imposes a natural scale-space on our perceptions. It blurs regions of our visual field and down-samples them, effectively rolling off high frequencies in the image. Put another way, stepping back from the image causes our eyes to first filter the data with a Gaussian filter and then shrinks the image. Since the Fourier transform of a Gaussian filter kernel is also a Gaussian in frequency space, this has the property of suppressing higher frequencies.

The hybrid Einstein-Monroe image has been altered, combining high frequency information from the Einstein portrait with low frequency information from the Monroe image. When seen at a near distance, the high frequency information dominates your perception. As you back away from the image, or as you down-sample it, reduce it in size, the lower frequencies are more apparent.

One aspect that often goes unmentioned is the amount of information that must be shared between the two images. There must be a wide range of information in mid-range and low frequencies that are common in both images. As such, the hybrid image carefully aligns the faces of Einstein and Monroe. In particular, the eyes are carefully aligned. The effect is also enhanced because both subjects have a halo of light-colored hair around their face.

##### **2. The task**

You are asked to generate your own hybrid image using two subject images of your own choosing. You may choose family members, famous photos, or even your pets. You may use whatever resources you have available to create the hybrid image. When complete, you should

post a written description of your process, how you filtered the images for high-frequency information and low-frequency information. Please include the settings for any filters that you used, particularly the scale parameters of any Gaussian filters you may have used.

- Post your written description of your solution to your assignment to BrightSpace.
- Send your resulting hybrid image to me via e-mail at [cos.computer.vision@maine.edu](mailto:cos.computer.vision@maine.edu)

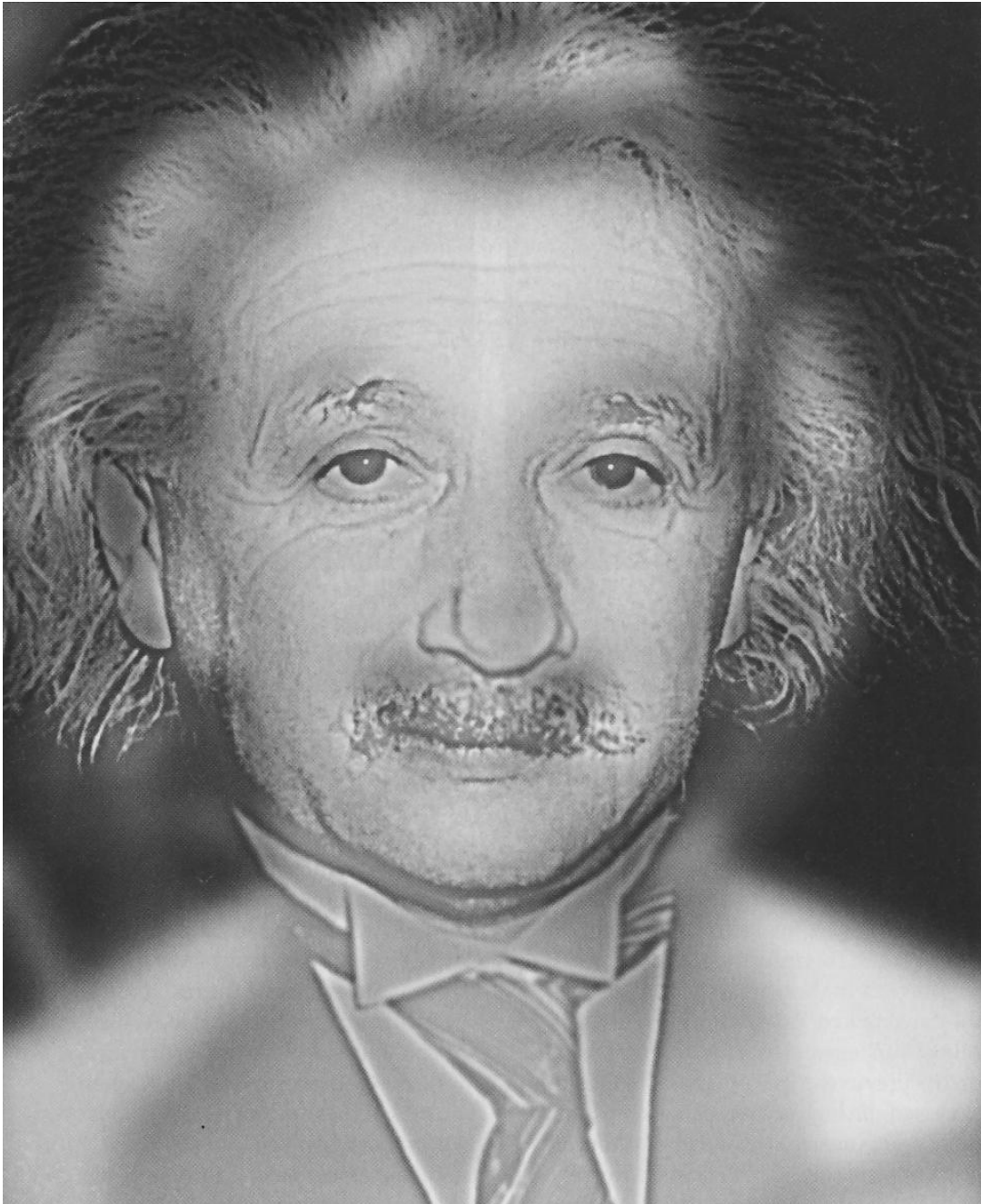


Figure 1. The Monroe-Einstein hybrid image illusion. This figure appears to be an image of Albert Einstein when seen closely. At a distance, the image appears to be the face of Marilyn Monroe. The image blends high and low frequency information from two images to achieve this effect. Copyright 2007, Aude Oliva, MIT.

### 3. Some resources

If you have not already done so, you can download FIJI (Fiji Is Just ImageJ), the free online image processing software application from the U.S. National Institutes of Health. This software was part of the SimpleITK tutorial, so you likely have already acquired it.

<https://fiji.sc>

There is an online web page with information that attempts to recreate the effect using the Fourier transform implementation in a software package called Maple.

<https://www.mapleprimes.com/maplesoftblog/209594-Hybrid-Images-Visual-Perception-And-Distance->

Maple is akin to MatLab. If you are so inclined, you can download a free trial version for this assignment, though it should not be necessary. MatLab will also have the available tools and filters to execute this assignment.

For step-by-step instructions on how to create a hybrid image using Adobe Photoshop, you can look up the following YouTube tutorial:

<https://www.youtube.com/watch?v=InfgUZ9Dnd0>

The YouTube tutorial mentions that it includes links to two sample images that you might use if you were going to recreate their example. You may use their images, but try to find your own.

Record the steps that you are making from source images to final copy. Especially report in your written remarks the parameters you used when filtering or adjusting the images.

### 4. My attempt.

I started with images of my son and my father. I took the color images of them both, and using the rotate tool in the Apple Photos application, I rotated the images until their eyes were level in both images. I converted both images to grayscale before exporting them. One could also use FIJI for the rotation and later export the images.

Cropping, translating and scaling the images is possible in FIJI, but I found it easier to import the images into Powerpoint and use the crop tools that it makes available. For one thing, it is possible to set your picture to be 50% transparent facilitating scaling and cropping.

After creating two cropped, aligned images, I imported both into FIJI again. I decided to make my father's image the distant, low frequency image, and my son the near, high frequency image. I used a Gaussian filter as a low pass filter for my father. I used the same Gaussian low pass filter on my son, then used the *Process/Image Calculator* to subtract the blurred low-pass image from the original picture on the assumption that what would remain would be the high frequencies. I lowered the brightness on my father's image, and used the *Process/Image Calculator* to add the low frequencies of my father's image with the high frequencies of my son's image.



a.



b.



c.

Figure 2. My attempt at a hybrid image of my father and my son. I used a mixture of tools. I first used Apple Photos for the initial rotation and to convert to grayscale, though I could have used FIJI. I used Microsoft Powerpoint to help translate and crop the images to created the aligned images show above in figures 2a. and 2b. I imported the results into FIJI where I used a combination of *Process/Filters/Gaussian Blur* and *Process/Image Calculator* to combine the two images for the result in 2c. When enlarged and viewed closely, image 2c has my son's features. At a distance or reduced, it strongly reflects my father.

#### 5. Your attempt(s).

There are no correct answers to this problem. The purpose of this exercise is to familiarize you with multiple techniques, to try different methods, and to explore the question of filtering, scale, and frequency space. Poke around FIJI, and see what filters and parameters work for you, and remember to record and report them.

**Submit the text part of your answers on Brightspace as either a PDF or MSWord document.**

**Submit any images via e-mail to [cos.computer.vision@maine.edu](mailto:cos.computer.vision@maine.edu).**

**Due 27-April-2022**